BERESKIN & PARR   **UNITED STATES**

Title: Risk Management System and Method Providing Rule-Based
Evolution of a Portfolio of Instruments

Inventors: JIM DEGRAAF
BEN DE PRISCO
TONY DOLEZAL

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FIELD OF THE INVENTION

[0001]   The present invention relates to a risk management system and method. More specifically, the present invention relates to a risk management system and method which provides for the analysis of risk of a portfolio of instruments wherein the portfolio evolves over time.

BACKGROUND OF THE INVENTION

[0002]   Risk Management systems are known and are commonly employed by financial institutions, natural resource-based corporations, trading organizations, government regulators or other users to make informed decisions to assess and/or manage the risk associated with the operations of the user.

[0003]   One popular example of a known risk management system is the RiskWatch V3.1.2 system, sold by the assignee of the present invention. This system is very flexible and allows users to employ models of the instruments in the user's portfolio, which models are evaluated at appropriate time intervals, in view of a set of possible scenarios. Each scenario comprises a vector of values for risk factors employed in the models, at each time interval, and each scenario has associated with it a probability of the scenario occurring. The resulting risk values of the instruments, when the models are evaluated under each scenario at each time interval of interest, are then used to produce one or more risk metrics which are examined to assess the risk to the user of holding the portfolio of instruments under the evaluated scenarios. The instruments which can be modeled and assessed by the system are is not particularly limited and merely requires that an adequate model can be defined for the instrument. Instruments can include, without limitation, various financial instruments such as equities, options, derivatives, etc. and can also include non-financial instruments such as reservoir capacities, insurance products, etc.

[0004]   Known risk management systems do however suffer from some problems. One of the more common problems is that portfolios being evaluated by prior art risk systems are generally modeled as static objects and yet portfolios change, or evolve, with time. For example, a bond in a financial portfolio can have one or more coupons which produce income at a specified time and thus the bond instrument evolves over time to become a bond instrument and a cash amount. As another example, a portfolio under consideration can include one or more options (for financial instruments, foreign exchange, commodities, etc.) that will be executed

when "in the money" to buy or sell the underlying commodity, thus changing the portfolio composition. In either of these cases, and in many others, the portfolio being analyzed by the risk system changes, perhaps significantly, as time passes.

[0005]   To date, the risk management systems and methods of which the present inventors are aware have not dealt well with the issue of portfolio evolution. Commonly, such systems have at best permitted the user to define a limited evolution strategy, for example specifying that the cash from a bond coupon will be re-invested into a pre-selected instrument, such as a money market account paying interest at the prevailing overnight interest rate, and have analyzed the risk under that assumption. In these systems, portfolio evolution is dealt with on a predefined, fixed, basis and, for example, the cash received from the bond's coupon discussed above will always be modeled as having been invested in the money market account (or whatever other instrument has been pre-defined by the user) even under scenarios wherein this will provide a poor investment return.

[0006]   In the real world, which the risk system is attempting to simulate, a user would re-invest this cash into an appropriate instrument, in accordance with market conditions at the relevant time. Under some market conditions, the cash could be invested in a 90 day US T-bill and in other conditions could be invested in the money market account, a bond, etc.

[0007]   In another example, a user can have a portfolio of short term bonds with mixed maturities which he wishes to perform various risk analyses on. Over some period of time of interest, such as a three to five year period, a significant portion of the bonds in the portfolio can mature. Prior art risk systems did not provide mechanisms whereby the maturity amounts of the bonds could be reinvested into instruments which were appropriate at the date of their maturing. Instead, the users of such prior art systems were forced to pre-define the re-investment instrument in a fixed manner, selecting a similar bond for example, even though under some particular scenarios under consideration this would represent a poor investment that the user would not actually make. Thus, prior art risk management systems are less accurate and less realistic at assessing risk of an evolving portfolio than is desired.

[0008]   Further, a user of a risk management system can have developed one or more potential trading strategies to evolve their portfolios appropriately under a variety of market conditions, such as strategies which specify which types of instruments to divest from and which types of instruments to invest in under various possible future scenarios. Prior art risk management systems do not allow such a user to evaluate how well these potentially competing strategies perform or their effect on the amount of risk resulting for the associated portfolios.

[0009] It is therefore desired to have a risk management system and method which permits a user to employ dynamic trading strategies using rules which effectively define how a portfolio of instruments will evolve over time and to permit the user to assess the performance of competing sets of trading strategies.

5 **SUMMARY OF THE INVENTION**

[0010] It is an object of the present invention to provide a novel risk management system and method which obviates or mitigates at least one disadvantage of the prior art systems.

[0011] According to a first aspect of the present invention, there is provided a
10 method of determining the risk associated with a portfolio of instruments for a set of scenarios of risk factors over a time period of interest, the composition of which portfolio can evolve over time to include different instruments and positions of instruments, comprising the steps of:

(i) defining at least one trading strategy for said portfolio, each said
15 strategy including at least one rule, least one tracked instrument, at least one tracked attribute applied to said rule, at least one target goal, at least one trading instrument and at least one funding instrument;

(ii) for each time of interest for each scenario in said set of scenarios, evaluating said at least one rule in each said at least one trading strategy, in view of
20 said at least one tracked attribute, in turn to determine if a test condition defined by said rule has been met;

(iii) when said test condition is met, changing the composition of said portfolio for subsequent consideration by simulating the execution of appropriate trades of said at least one trading instrument to achieve said at least one target goal
25 and employing said changed; and

(iv) producing a risk metric for said portfolio, encompassing said changed composition.

[0012] According to another aspect of the present invention, there is provided a dynamic portfolio of instruments for use with a risk system, the composition of said
30 portfolio being changeable with time, the portfolio comprising:

a holdings structure indicating instruments and their quantity in the portfolio; and

a strategy structure indicating at least one trade manager, each said trade manager including a rule defining a condition which can be evaluated in view of
35 at least one attribute and each said trade manager altering the quantity of at least one said instrument in said portfolio to achieve a target attribute for said portfolio when

evaluation of said rule results in said condition being met.

[0013]   According to yet another aspect of the present invention, there is provided a risk management system operable on a set of instruments and a set of scenarios, each scenario including risk factor values and a scenario probability, said system comprising:

at least one risk engine operable to determine a risk value for each instrument in said set of instruments, said risk value determined by evaluating, in view of said risk factors in said scenario, a model stored for said instrument;

a database to store each said determined risk value;

at least one dynamic portfolio including at least one trade manager, each trade manager including a rule corresponding to one of said at least one user-defined trading strategies and said trade manager evaluating said rule in view of at least one attribute relating to said portfolio and said scenarios and altering the composition of said portfolio in accordance with said at least one trading strategy when the conditions of said rule are met; and

an aggregating engine to retrieve said determined risk values and said scenario probabilities for said portfolio to produce a risk metric corresponding to the compositions of said portfolio.

[0014]   The present invention provides a risk management system and method for the establishment of dynamic portfolios, whose evolution over time is defined by one or more rules. Each dynamic portfolio can have the quantities of the instruments in the portfolio increased or decreased, including the total removal of instruments from the portfolio and/or the addition of new instruments to the portfolio, thus changing the composition of the portfolio. Trading strategies are defined by a user to define how the dynamic portfolio should evolve and one or more Trade Managers implement these strategies. Each Trade manager evaluates one or more user-defined rules which can be dependent upon various attributes, including time, portfolio contents, risk factor values, risk values or other information and changes the contents of the portfolio in accordance with the trading scenario. Such dynamic portfolios can be used to analyze risk associated with settlement, liquidity and/or collateral management issues, to name a few. Also, a user can define multiple candidate trading strategies, each implemented in one or more Trade Managers, and the user can then analyze the effectiveness of the candidate strategies, before adopting one.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]   Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 shows a risk management system in accordance with an embodiment of the present invention, including a dynamic portfolio;

Figure 2 shows the dynamic portfolio of Figure 1 in more detail;

Figure 3 shows a Trade Manager of the dynamic portfolio of Figure 2;

5   and

Figure 4 shows a flowchart of the process of evaluating and updating a dynamic portfolio.

DETAILED DESCRIPTION OF THE INVENTION

[0016]   In co-pending U.S. patent application filed June 2, 1999, accorded serial

10   number • and assigned to the assignee of the present invention, a novel risk management system is disclosed and the contents of this reference are incorporated herein by reference. As shown in Figure 1, this novel risk management system 20 can include one or more risk engines 24 which operate on models of instruments employing risk factors and the values of these risk factors are defined in scenarios

15   that are stored in a database 28. Risk engines 24 evaluate the models with the corresponding sets of risk factor values of a scenario to determine risk values for the scenario which are also stored in database 28. System 20 further includes one or more aggregation engines 32 which operate to retrieve determined risk values from database 28 to determine appropriate risk metrics for a portfolio of the instruments

20   stored in database 28.

[0017]   As described in detail in the above-mentioned co-pending United States patent application, database 28 stores determined risk values at the leaf level, i.e. - for each individual instrument or for pre-selected groups of instruments, as well as storing other information of interest, such as risk factor values, derived risk metrics,

25   determined credit exposures, etc. This allows aggregation engines 32 to examine a variety of portfolios of instruments, without necessarily requiring the re-calculation of risk values for each instrument in the portfolio under consideration. Portfolios of instruments can be pre-defined and stored in database 28, or elsewhere, for use by aggregation engine 32 or can be created on an ad-hoc basis by a user. This allows a

30   user to examine the effect that different portfolio make ups can have on various risk metrics for the portfolios or to determine the marginal risk associated with a proposed transaction or to analyze risk at various levels of an enterprise without requiring recalculation of risk values for instruments in the portfolios.

[0018]   In an embodiment of the present invention, system 20 further includes

35   one or more dynamic portfolios 100 which interface with aggregation engines 32 and Figure 2 shows a dynamic portfolio 100 in more detail. A dynamic portfolio 100 is one

whose evolution with time is defined by one or more rules. As shown, dynamic portfolio 100 includes a Holdings structure 104 and a Strategy Definitions structure 108. Holdings structure 104 defines all of the instruments which are held in the dynamic portfolio and the position (i.e. - how many short or long, or a flat position) held in those instruments in the portfolio. Holdings structure 104 includes a pointer 112 to each position 116 of a respective instrument 120 (or pre-defined group of instruments) in dynamic portfolio 100 and positions 116 can change, according to specified rules, under specific scenarios.

[0019] Strategy Definitions structure 108 includes a pointer 124 to each Trade Manager 128 in dynamic portfolio 100, wherein a Trade Manager 128 is created and maintained for each trading strategy implemented by dynamic portfolio 100. Each Trade Manager 128 has one or more rules, or conditions, defined for it and which it examines and operates on to initiate trades to increase or decrease positions 116 of instruments within dynamic portfolio 100. For example, a Trade Manager 128 can be defined with a rule that indicates that when a bond coupon matures, the resulting cash is to be invested in either money market account or 90 day U.S. Treasury bills (T-bills), depending upon which instrument has a higher yield at the appropriate time, under the scenario that the dynamic portfolio 100 is being considered at. Dynamic portfolio 100 can include multiple Trade Mangers 128, as desired, to implement multiple trading strategies. For example, a second Trade Manager 128 can be defined, in addition to the above-mentioned Trade Manager 128 which tracks and operates on bond coupons, wherein the second Trade Manager 128 tracks the delta (volatility) of equity option instruments in dynamic portfolio 100 and initiates trades to purchase the underlying equities as hedges, to reduce the delta for this portion of dynamic portfolio 100 to a pre-selected level.

[0020] Figure 3 shows a Trade Manager 128 in more detail. As shown, each Trade Manager 128 includes a Rule structure 160, a Tracked Position list 164, a Tracked Attribute list 168, a Target Vector 172, a Trade Position list 176 and a Funding Position list 180, each of which is described in further detail below.

[0021] As mentioned above, each Trade Manager 128 allows a user of risk system 20 to define one or more rule-based trading strategies by which a portfolio will be evolved over time. Rule structure 160 holds the rule, or rules, for a particular strategy. In a present embodiment of the invention, these rules are defined in a grammar and/or scripting language, although any other suitable method of defining such rules can be employed as desired. When evaluated in a scenario, each rule accepts one or more input attributes, which can be risk factors defined for the scenario, risk values derived under the present scenario or other information available

under the scenario, such as the make-up or contents of the portfolio or foreign exchange rates, etc.

[0022] An English language example of a rule could be, "If the delta of the options for NASDAQ-listed equities in the portfolio exceeds 0.5, then purchase

5 corresponding underlying equities until the total delta for the equities and the options does not exceed 0.5", although the rule would be written in an appropriate form for consideration by Trade Manager 128.

[0023] Tracking Position list 164 indicates the instruments and/or positions which are tracked by the Trade Manager 128 when evaluating a rule or rules in Rule

10 structure 160. In the example of the Trade Manager for controlling the delta of the options for NASDAQ-listed equities options discussed above, Tracking Position list 164 will indicate each option and its position in dynamic portfolio 100 and each equity that is added to the portfolio to alter the delta of the combined holdings in equities and options.

15 **[0024]** Tracking Attribute list 168 indicates the particular quantity or quantities which are tracked by Trade Manager 128 and which should therefore be determined or otherwise be available to Trade Manager 128. In particular, these can be risk factors which are defined for the particular scenario under consideration, instruments and/or positions or any other underlying information for the scenario under

20 consideration. In the example of the Trade Manager 128 for the delta of the options and their underlying NASDAQ-listed equities, discussed above, Tracking Attribute list 168 indicates the delta of those options and equities which must be calculated by Trade Manager 128 or which can be a defined risk factor in a scenario under consideration.

25 **[0025]** Target Vector 172 indicates the result, or results, which are desired from trades implemented by Trade Manager 128 for each entry in the Tracking Attribute list 168. For example, Target Vector 172 can indicate that a delta of 0.5 or less is desired for combined holdings of options and equities listed in Tracking Position list 164.

30 **[0026]** Trade Position list 176 indicates the instruments and their positions which can be traded in dynamic portfolio 100 to achieve the desired targets defined in Target Vector 172 and the number of trade positions entered in Trade Position list 176 is equivalent to the number of tracking attributes listed in Tracking Attribute list 168. In the NASDAQ-listed options and equities example, Trade Position list 176 will list the

35 equities corresponding to each call or put option in the Tracking Position list 164 that are to be purchased or sold to achieve the desired delta for the holdings.

[0027] Finally, Funding Position list 180 lists the instruments and positions

which can be traded to fund trade strategies implemented by Trade Manager 128. For example, the Funding Position list 180 can list very liquid instruments, such as cash in a money market account, or short term T-bills, etc. which can be sold or purchased to fund trades initiated by Trade Manager 128. In the above-mentioned example of the options and NASDAQ-listed equities, appropriate amounts of the instruments in Funding position list 180 will be traded to fund the purchase or sale (as appropriate) of the required underlying equities to achieve the desired delta for the holdings.

[0028]   As will be apparent to those of skill in the art, the positions in dynamic portfolio 100 are updated accordingly after the purchase and sale trades initiated by Trade Manager 128 are performed, including the purchase or sale of any instruments on Funding Position list 180. As will also be apparent to those of skill in the art, Tracking Position list 164, Trade Position list 176 and Funding Position list 180 can each refer to some or all of the same instruments and positions. For example, an instrument included in Tracking Position 164 to determine an attribute for a rule in Rule structure 160 can also be included in Trade Position list 176 so that it can be sold, or additional amounts purchased, as appropriate.

[0029]   In a present embodiment of the invention, a rule or rules defined in Rule structure 160 can be of any one of five types, namely: a band rule; a barrier rule, a comparison rule; a functional rule; and a composite rule, and each rule or set of rules returns a "TRUE" value when the condition of interest is present in the portfolio under the present scenario and time and a "FALSE" value at all other times. A Trade Manager 128 only initiates trades when it's rule, or rules, are TRUE.

[0030]   A band rule defines a trigger band for an appropriate attribute and tests that the current value of that attribute is within the trigger band or without (as selected by the user when defining the rule). This type of rule can be used to test for an attribute's value moving outside of, or into, a specified range. A barrier rule defines a trigger level which the attribute either should not be above or should not be below (as selected by the user when defining the rule). A comparison rule defines a comparison between values, such as risk factors or derived values, and is TRUE when the value of a first user selected attribute exceeds the value of the other user selected attribute. A functional rule allows a user to define a script or function which is evaluated to determine if the rule is TRUE. Functional rules allow rules to be based upon a variety of attributes, both those derived by the function and those operated on by the function. Finally, a composite rule allows a user to define a composite rule employing the above-mentioned other types of rules which are combined with boolean operators such as AND, OR, NOT and XOR (Exclusive OR).

[0031] In the present invention, values used for trigger levels, trigger band points, target values in Target Vector 172, etc. can be absolute (e.g. - 0.5) or relative (e.g. - 5% of the total value of the portfolio), as desired. This allows, for example, an index tracking target to be defined for a dynamic portfolio, such as a dynamic portfolio of bonds that can be created to track, within a specified range, the "duration" of the Morgan Stanley Bond Index.

[0032] The present invention also provides filters for use with rules and such filters can allow dynamic, or otherwise sophisticated, rules to be created. For example, a filter can be applied to the Tracking list in a Trade Manager to remove from consideration, when evaluating the rule, any instrument which comprises less than one percent of the total value of the portfolio.

[0033] Multiple strategy dynamic portfolios can be implemented with single rule or multiple rule Trade Managers 128, or both. Specifically, if two or more rules can share a single solution, they can be defined in a single Trade Manager 128 which will simultaneously evaluate the rules and implement trades to achieve the desired results specified in the Target Vector 172. For example, Rule structure 160 and Target Vector 172 can define that: (i) a delta for certain holdings in the portfolio not exceed a specified amount; and (ii) that cash on hand should not exceed a certain percentage of the total value of the portfolio. Clearly, one or more solutions exist which would meet both of these requirements.

[0034] In contrast, in circumstances wherein meeting the requirements of one rule can impact the success of meeting the requirements of a second rule, each rule is employed with a separate, prioritized, Trade Manager 128. For example, a first rule can require that foreign content of a portfolio not exceed twenty percent of the total present value of the portfolio to meet regulatory requirements. A second rule can require that the delta of combined holdings of options and their underlying foreign instruments not exceed a specified amount. It is clear that these two rules can be in conflict, for example if the first rule would result in the sale of some of the underlying equities to reduce foreign content while the second rule would result in the purchase of additional (possibly foreign content) underlying equities to reduce the delta of the holdings.

[0035] To prevent such conflict of rules from occurring, Trade Managers 128 also have a priority assigned to them wherein Trade Managers 128 with higher assigned priority numbers are processed before Trade Managers 128 with lower assigned priority numbers. In the above-mentioned example, the Trade Manager 128 with the foreign content rule can have a priority of two assigned to it, as the regulatory requirement must be met, and the Trade Manager 128 with the delta level

rule can have a priority of one assigned to it. In this example, the priority one Trade Manager 128 is first executed, buying additional foreign content equities if required. Next, the priority two Trade Manager 128 is executed, divesting the portfolio of foreign content, even including equities just purchased by the priority one Trade Manager 128, until the regulator-imposed foreign content requirement is met. In fact, in a present embodiment of the invention the execution of all Trade Managers 128, even those with multiple rules, is prioritized. As will be apparent to those of skill in the art, the combination of multiple rule Trade Managers and prioritized evaluation of Trade Managers 128 allows sophisticated trading strategies to be defined and implemented by a user.

[0036]   Figure 4 shows a flowchart of the process of evaluating a dynamic portfolio 100. The process commences at step 200 wherein the Trade Manager 128 with the highest assigned priority number in dynamic portfolio 100 is selected for processing. At step 204, all of the attributes in Tracking Attribute list 168 of the Trade Manager are retrieved. As mentioned above, in system 20, database 28 stores risk factor values for each scenario at each time of interest and stores determined leaf level risk values (or aggregated value totals for pre-selected groups of instruments) for all instruments of interest. Instruments of interest include both those in any portfolio and those which can be included in a portfolio due to the operation of dynamic portfolios and those which the administrator or other manager of database 28 believes might be of interest to users.

[0037]   Thus, at step 204, the selected Trade Manager 128 queries aggregation engine 32 to retrieve the required attribute values from database 28 or to determine derived values by invoking a risk engine 24, as needed. At step 208 the rule, or rules in the case of a multiple rule Trade Manager, in Rule structure 160 is evaluated with the attribute values. At step 212, a determination is made as to whether the rule, or rules, in Rule structure 160 is TRUE. If the rule or rules are TRUE, the Trade Manager updates the positions in the dynamic portfolio, to simulate appropriate trades, of those instruments indicated by the Trade Position list 176, to obtain the targets indicated by Target Vector 172, while updating the positions of the appropriate instruments indicated by Funding Position list 180, as required.

[0038]   Once the processing of step 216 is complete, or if the rule or rules, evaluated at step 212 are not TRUE, the process proceeds to step 220 wherein a determination is made as to whether any Trade Managers remain to be considered for dynamic portfolio 100. If one or more Trade Managers do remain to be considered, the next lower priority Trade Manager is selected at step 224 and the process of steps 204 through 220 is repeated. If no Trade Managers remain to be considered at

step 220, then at step 228 the process completes. The process of Figure 4 is repeated for each dynamic portfolio 100 under consideration by system 20.

[0039] In many circumstances, the instruments on Trade Position list 176 or Tracking Position list 164 may not exist while dynamic portfolio 100 is being processed. For example, dynamic portfolio 100 can be processed for a five year period of interest, i.e. - the user wishes to assess risk or evaluate the effectiveness of a trading strategy for each month over a five year term. In such a case, one or more instruments, such as a three month equities option, may need to be available for Tracking Position list 164 or Trade Position list 176 for relevant time periods several years out from the present. As these instruments will not exist in the present, they must be simulated for inclusion in these lists. Accordingly, generic models of such instruments are provided to system 20, and usually stored in database 28, and are evaluated in view of risk factor values and other relevant information as needed for each scenario and time of interest to simulate the needed instruments. In operation, dynamic portfolio 100 will merely request the needed information from an aggregation engine 32 which, if the information is not available in database 28, will invoke a risk engine 24 to process the appropriate model to obtain the needed simulated information. This simulated information can also be stored in database 28, once it is calculated, and passed to aggregation engine 32 and dynamic portfolio 100 as needed.

[0040] Once the process of Figure 4 is complete, an aggregation engine 32 can determine the desired risk metrics for dynamic portfolio 100, by itself or in combination with other portfolios and/or dynamic portfolios, in view of its updated positions. Again, should risk values for one or more instruments, needed to produce the desire risk metrics, be missing from database 28, a risk engine 24 can be invoked by aggregation engine 32 to determine the missing value or values, which can then be stored in database 28 for future use. Provided that models for these instruments are available, and that all necessary risk factors for those models are defined within the available scenarios, this invocation of risk engine 24 will generally be transparent to the user.

[0041] As will be apparent to those of skill in the art, since the aggregation engine 32 which produces the desired risk metrics for a dynamic portfolio 100 accomplishes this in most circumstances by merely retrieving previously calculated risk values from database 28, the evaluation of a dynamic portfolio 100 can be accomplished relatively easily, without requiring excessive computational resources. Thus, many dynamic portfolios 100 can be evaluated in a relative short period of time. Further, as multiple aggregation engines 32 can be present in system 20, dynamic

portfolios 100 can be evaluated in parallel, if desired.

[0042]   It is contemplated that a user can define a portfolio comprising one or more dynamic portfolios, as sub-portfolios, or that an entire portfolio can comprise a dynamic portfolio. This flexibility allows a user to model a portfolio in a manner which

5   more accurately reflects the evolution of the portfolio over time. It is however, further contemplated that users can examine the effects of different trading strategies on their portfolios. Specifically, a user can define two or more dynamic portfolios, each dynamic portfolio having the same initial composition of instruments and positions, but having a different trading strategy or trading strategies defined for it. The user can

10   then evaluate suitable risk metrics from each dynamic portfolio to assess the performance of each trading strategy or set of trading strategies. Depending upon the results of this evaluation, the trading strategy that best suits the needs of the user can be selected by the user for use in future trading operations.

[0043]   One of the factors which can influence the way in which a portfolio

15   evolves with time, and the risk associated with the portfolio, is the liquidity of underlying instruments. For example, the longer time period required to sell a position in an instrument or to hedge a position in an instrument, the greater the risk. Conventionally, prior art risk management systems have dealt with liquidity issues by making a broad assumption, such as assuming that a position in an instrument can be

20   sold within a selected number of days, for example many regulatory regimes require an assumed ten day period in which to divest a position, or that hedging the instrument will require a specified number of days to accomplish. Such assumptions are generally poor ones as they ignore changes in market conditions, which can be the most significant factor affecting the liquidity of many instruments. Further, such

25   assumptions are generally the same for all instruments in a portfolio, even when such an assumption is wildly pessimistic (for example, for a highly liquid foreign exchange position) or wildly optimistic (for example, for a position in a little traded corporate bond that may take weeks or more to sell). It will be apparent that prior art risk management systems have not represented liquidity issues in an effective manner.

30   **[0044]**   In contrast, in the present invention the Trade Position lists 176 of appropriate Trading Managers 128 can include limitations, to obtain a more accurate model of liquidity-related risks, by limiting the amount of an instrument which can be sold or purchased at any one time. These limitations can be absolute, i.e. - permitting no more than 100 units to be bought or sold in the time period of interest, or can be

35   relative, i.e. - permitting no more than 10% of total trading volume in that instrument to be bought or sold in the time period of interest. Further, a dynamic portfolio can be defined with a trading strategy having two rules and when a first of these rules is

TRUE, requires the instrument to be sold and when the second of these rules is TRUE, requires the purchase of a hedge against the instrument. The rules can track appropriate attributes, such as market volatility, total trading volumes, etc. to determine when it is more appropriate to sell or hedge the instrument. These rules can be combined with the above-mentioned limitations (i.e. - can sell no more than 10% of total trading volume in the instrument each day or a hedge can only be purchased on any day for a percentage of the position held, that percentage depending upon the amount of change in the instrument's value on the preceding day, etc).

[0045] Thus, liquidity considerations can be more accurately modeled with system 20 and, as a portfolio is processed, the liquidity-related delays in executing trades (i.e. - cash flows, instrument purchases and sales, etc.) which can be time and scenario dependent, are fully incorporated into the risk metrics produced.

[0046] Another use of the present invention is for the management of collateral risk. Specifically, in many circumstances a borrowing entity will provide appropriate amounts of collateral to a lending organization to offset the lender's risk of lending funds to the borrower. In the past, many lending organizations did not recognize or consider the actual risk associated with the delivery of such collateral. Specifically, it was often assumed that collateral would be delivered simultaneously with an increase in risk. In fact, often a change in risk associated with such a loan would not be recognized for some period of time, such as a day or more, while the new level of risk was being determined. Then, once a margin or collateral call was made by the lending organization, the borrowing entity often had three or more additional days to deliver the collateral. If the required collateral was not delivered on time, typically negotiations and/or discussions would occur between the lender and the borrower which often added several more days before a resolution occurred. Of course, the risk associated with recovering the loaned funds from the collateral can increase significantly with such an increase in time.

[0047] In the present invention, such collateral risk can be included in a risk assessment. Specifically, one or more positions 116 referred to by Funding Position 180 can be defined such that they are only available N periods of time (usually days) after it is desired to sell them. For example, in a margin call example, N can be set at four days for such collateral positions and thus risk metrics determined with such positions will more accurately reflect the actual risk to the lender. In one embodiment of the present invention, one or more Trade Managers 128 can include multiple "Cash on Hand" positions that can be time-shifted as appropriate. For example, a margin call at time period T=0 to sell collateral instruments will result in a credit of funds into the Cash on Hand position at time period T=4 (assuming T is expressed in days and

assuming a four day collateral delivery period). When risk metrics are assessed for time period T=4, the total available Cash on Hand position will include the sum of any remaining previously available cash and the cash from the sale of the collateral. Thus, risk metrics determined for time periods T=1, T=2 and T=3 will clearly reflect the fact that the funds from the margin call collateral at T=0 are not yet available.

[0048] In fact, by creating one or more Trading Managers 128 where N differs, a user can assess the effects of additional delay (allowing for contact and negotiations with the borrower, for example) on the risk to the lender under different market conditions. Thus a lender can recognize that, for the same ultimate level of risk, under some market conditions N can be a large number (e.g. - ten days), so that the lender can negotiate to resolve an issue with a borrower for some period of time, and that under other market conditions N might be a small number (e.g. - three days) so that the lender effectively has no time to negotiate and must take immediate steps to realize on the collateral.

[0049] Further, the above-mentioned liquidity-related risks can be incorporated in an analysis of collateral management risks by appropriately modeling the liquidity in the instruments in the dynamic portfolios. This can be a important advantage of the present invention, as margin calls or the like often occur when a significant movement has occurred in the price of an instrument and such significant movements can reduce the liquidity of the instrument, thus exacerbating the risk of realizing on the collateral at a given price.

[0050] The present invention allows a user to accurately determine risk metrics of interest for a portfolio which evolves over time. The user can define rules which are used to implement various trading strategies by which a portfolio can change with time and in response to risk factors or other attributes. A user can also define and test a variety of potential trading strategies to determine their performance and suitability for use. Appropriate trading strategies can be employed to model settlement risk, liquidity risk and collateral management risk.

[0051] The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.